Continuous Emissions Monitoring System (CEMS)

QUALITY ASSURANCE/QUALITY CONTROL PLAN

(QA/QC Plan)

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- California Air Resources Board (CARB) Amendments and Public Comments, June, 1988
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- SCAQMD CEMS Final Certification Letter, June 28,1994
- US Environmental Protection Agency (EPA) Title V Permit to Operate – Permit No. CB-OP 99-01, August 1, 2000
- US Environmental Protection Agency (EPA) Approval to Modify, Including Amendments through August 14, 2003; refers to 40 CFR 60 Performance Specifications
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- SCAQMD Form ST-220 CEMS Modification Application, Boiler 1, January 10, 2014
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Appendix C – CEMS Components Manufacturers Manuals

- CiSCO System Manual
- Universal Analyzers Model 1090 Sample Cooler Manual
  - http://www.universalanalyzers.com/Manuals/man1090revg.pdf
- California Analytical Instruments ZRE NDIR/O_2 User's Manual
  - file:///C:/Users/Priority%20One%20CEMS/Documents/Priority%20One/Desert%20View/ZRE_CAI_OPERATORS_MANUAL.pdf
- Ametek/Thermox Model WDG-Insitu Flue Gas Analyzer Manual
- Teledyne Monitor Labs Lighthawk 560 Dual Pass Opacity Manual
  - http://www.teledyne-ml.com/pdf/lh560manual.pdf
- Dieterich Standard Model 70 Annubar Manual
- CiSCO CeDAR User's Guide
  - http://www.ciscocems.com/index.php?option=com_k2&view=item&id=32:downloads&Itemid=53

Related Reference Material

Refer to the following manuals for additional information located under separate cover.

Code of Federal Regulations, Title 40, Part 60 (40 CFR 60)
http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&tpl=%2Findex.tpl

EPA/CAMD CEMS Field Audit Guide (Note: geared for Part 75 Acid Rain Program but still useful for Part 60 applications:
http://www.epa.gov/airmarkets/emissions/audit-manual.html

South Coast Air Quality Management District Rule 218
http://www.aqmd.gov/rules/reg/reg02/r218.pdf

South Coast Air Quality Management District Rule 218.1
http://www.aqmd.gov/rules/reg/reg02/r218-1.pdf

DAHS software manual

CEMS Operation and Maintenance Manual, including vendor material as appendices.

EPA's Emission Measurement Center, use to download copies of EPA test methods:

http://www.epa.gov/ttn/emc/

EPA's gateway page State regulatory websites:

http://www.epa.gov/epahome/state.htm

Federal Register Air Programs website – periodically check for new postings on proposed revisions and/or final rulings on air regulatory programs:

http://www.epa.gov/fedrgstr/EPA-AIR/index.html

1 Overview

1.1 Introduction

This document is intended to satisfy the requirements of the South Coast Air Quality Management District (SCAQMD) as required by SCAQMD Rule 218 and 218.1, which requires that a quality control program be developed and implemented for the continuous emission monitoring systems (CEMS) and related components.

The objective of the Quality Assurance / Quality Control Plan (QA/QC Plan) to establish a series of Quality Assurance (QA) and Quality Control (QC) activities that will provide a high level of confidence in the data reported by the CEMS. The QAP provides guidelines for implementing QA and QC activities needed to ensure that emission monitoring data are complete, representative, and of known precision and accuracy.

South Coast Air Quality Management District (SCAQMD) Rule 218 (Continuous Emission Monitoring) establishes the requirement for a QA/QC Plan for these (non-RECLAIM) CEMS. Rule 218 defines a QAQCP as "*a written document in which the specific procedures for the operation, calibration and maintenance of a certified Continuous Emissions Monitoring System (CEMS) are described in detail, including additional quality assurance assessments and the corrective action system. The purpose of this plan is to ensure that the CEMS generates, collects, and reports valid data that is precise, accurate, complete, and of a quality that meets the requirements, performance specifications, and standards of Rules 218 and 218.1.*"

1.2 Quality Assurance Policy

It is the policy of Desert View Power, Inc. to adhere to all applicable rules and regulations as set forth in SCAQMD Rules 218 and 218.1. All necessary air emission data are obtained in order to demonstrate compliance with data quality objectives. The QA/QC Plan establishes operational procedures that will ensure these data and measurements are accurate and precise. Facility personnel will strive to keep the CEMS in proper operation a minimum of 95% of facility operating time. At no time will non-quality assured data be reported as valid data.

Definition of Quality Control and Quality Assurance

A QA/QC Plan is a document that establishes procedures for both Quality Control and Quality Assurance. Quality Control is the system of activities to provide a quality product (that is, air pollution emission measurements). Quality Assurance is the system of activities to provide assurance that the Quality Control system is performing adequately.

Quality Control (QC): The procedures, policies, and corrective actions necessary to ensure product quality. QC procedures are routine activities. These activities include but are not limited to daily calibrations drift checks and routine preventive maintenance activities as defined by manufacturers of the various hardware components of the CEMS and by regulatory agencies.

Quality Assurance (QA): A series of checks performed to ensure the QC procedures are functioning properly. Quality Assurance is often used to define "external" activities (that is functions performed on a more occasional basis). The activities include but are not limited to required periodic quarterly and annual audits.

1.3 QA/QC Audit Procedures

QA/QC Audit Procedures consist of checks and audits performed on the CEMS on predetermined as well as "as-needed" bases (for the basis of this plan as needed checks and audits will be triggered by system alarms either warning or out of control (OOC)). The resulting assessments may indicate the need for additional QC measures and/or corrective actions. After the corrective actions are performed, the data quality is again assessed. The quality of the data determines whether the corrective actions were successful.

The following is a brief overview of the type and frequency of QA/QC procedures, as outlined in SCAQMD Rule 218.1.

CEMS QA/QC Audit Procedures and Frequencies

CEMS QA/QC Audit Procedures and Frequencies			
Procedure	daily	1/4-ly	Annually
24 hr. Calibration Error (CE) Test SCAQMD Rule 218.1 (b)(4)(A)	X		
Cylinder Gas Audit (CGA), all gas analyzers (a) SCAQMD Rule 218.1 (b)(4)(D)		X	
Relative Accuracy Test Audit (RATA), all analyzers SCAQMD Rule 218.1 (b)(4)C			X
NO2 to NO Converter Efficiency Test to be performed in conjunction with the RATA (b)			X
Sample System Bias Test to be performed in conjunction with the RATA SCAQMD Rule 218.1 (b)(4)(B)			X

Notes:

(a) CGA is sometimes referred to as a Cylinder Gas Audit, and other times as a Calibration Gas Audit.

(b) An annual NO2 to NO converter efficiency test is not required by 218 or 218.1 and has been inserted into this document upon request of SCAQMD Source testing.

This QAP, in summary form only, addresses all necessary support services and activities, such as reference method testing, data reduction, and report preparation. Consult knowledgeable personnel (E&I technicians), regulations, and Operation and Maintenance (O&M) manuals for further information.

This QAP covers both QC and QA activities and procedures, and where feasible, identifies activities as "QC" or "QA".

1.4 Document Control

As a controlled document, this QAQCP will be reviewed on at least an annual basis and will be updated as needed to reflect changes in regulatory requirements, organization, personnel, equipment, responsibilities, and procedures as those changes occur. Updates will also include changes in the frequency and nature of scheduled maintenance activities demonstrated to be necessary based on actual experience with operating the system.

When revisions to the QAQCP are necessary, responsible facility personnel will be designated to ensure the revisions are made and that copies of the revisions are distributed to all individuals and groups that need to be aware of such changes. A record of all plan revisions and annual plan reviews will be maintained in Appendix A.

The following document control headers and footers are provided on each page as a means to recognize that a QAQCP document contains the most recent information available:

- Page No.
- Revision No.
- Revision Date

The plant operating procedures, equipment operation and maintenance manuals, and other documents that are referenced in this QAQCP are not controlled documents and therefore are not subject to this document revision procedure.

2 Facility and CEMS Description

2.1 Facility Description

The Desert View Power Facility is a Biomass Fired Plant with 2 boilers, rated at a total of 47 MW, located on Gene Welmas Drive in Mecca, California (SCAQMD Facility ID # 100154).

2.2 CEMS System Description

The facility has two continuous emissions monitoring systems (CEMS). The CEMS are fully extractive systems.

The CEMS measures concentrations of sulfur dioxide (SO_2) carbon monoxide (CO), carbon dioxide (CO_2), oxides of nitrogen (NOx), wet and dry oxygen (O_2), opacity, and stack flow. All measurements are done on a real time basis.

The CEMS includes a programmable logic controller (PLC). The PLC communicates, via Ethernet, from the CEMS to the Data Acquisition and Handling System (DAHS) computer. The PLC transmits one-minute averages. Contact closures are provided for alarms and system status.

The system operates automatically so operator attention is necessary only for manual verification of accuracy and normal maintenance.

Analyzers Included in the CEMS

CEMS Analyzer Data				
analyte	manufacturer, model	range(s)	units	serial #
NOx	California Analytical Instruments (CAI) ZRE-C2COS2NOO2P	0 - 100	PPM	CEMS #1: A3F4992T CEMS #2: A3F4993T
		0 - 500	PPM	
SO2	CAI ZRE-C2COS2NOO2P	0 - 50	PPM	
		0 - 500	PPM	
CO	CAI ZRE-C2COS2NOO2P	0 - 100	PPM	
		0 - 500	PPM	
CO2	CAI ZRE-C2COS2NOO2P	0 - 20	%	
Dry O2	CAI ZRE-C2COS2NOO2P	0 - 25	%	
Wet O2	Ametek/Thermox WDG Wet O2	0 - 25	%	CEMS #1: C079037-2 CEMS #2: C079037-1
Opacity	Teledyne Monitor Labs Lighthawk 560 Dual Pass Opacity	0 - 100	%	5600142
Stack Flow	Dieterich Standard Model 70 Annubar	0 - 20	MDSCFH	

Sample System Overview

To ensure accuracy, a clean, dry representative gas sample must be transported to the analyzers. Any moisture or particulate matter can cause damage to the gas analyzers so it must be removed from the sample. The following describes the function and operation of major system components arranged according to the normal flow of sample gas from sample probe to gas analyzers.

Sample Probe

The CISCO heated stack filter assembly and probe is designed for continuous extraction of gases with sample flow rates of up to 20 liters per minute. The filter assembly, which provides the first stage of sample conditioning, is mounted in a stainless steel housing which is heated to 300°F and is in direct contact with the outside environment.

Sample Line

The heat-traced sample line transports sample gas from each sample probe enclosure to a Main Analysis Enclosure. This line maintains the sample gas above the dew point, preventing the moisture in the sample from condensing.

The line contains several tubes. Depending on the application, these lines may be made of Teflon, Stainless Steel, or Perm-Bar. Please note that Perm-Bar has a temperature limitation of 250°F, while Teflon has a temperature limitation of 425°F.

The first tube (3/8") transports sample gas to the Main Analysis Enclosure. The second tube (1/4") transports instrument air for a probe purge. The third tube (1/4") transports calibration gas for a probe calibration. The heat-traced sample line is insulated with inorganic fiber material and covered with a freeze-protected jacket.

Sample Gas Cooler

The Universal Analyzers Model 1090PV Thermoelectric Sample Cooler uses impinger type heat exchangers. These are mounted within heat transfer blocks that are cooled by thermoelectric elements utilizing the Peltier Effect. In the Model 1090PV Sample Cooler, the first set of the heat transfer blocks is cooled by direct contact with the air-cooled heat sink. The second set of the heat exchangers through which the sample passes is cooled by the use of a Thermoelectric Element at a controlled temperature. The factory setting is +5°C. Temperature is measured by a type K thermocouple sensor and regulated electronically. The heat energy emitted by the cooling system is discharged by the air-cooled heat sink. Solids are trapped in the sample probe filter as well as in a downstream fine filter.

Cooler Drain Pumps

Two peristaltic pumps continuously drain the condensation moisture traps. The pumps are activated by a fixed-speed drive, rotating at 6 RPM.

In-Line Filter

Sample gas flows through an in-line filter, removing particulates that could damage downstream components. The filter is of the fine in-line type, which can trap particles as small as 2.0 micron.

After flowing through the filter, the sample gas flows past the vacuum gauge. Maintenance intervals will depend upon quantity of particulate matter at point of sample extraction. The site specific maintenance intervals will be determined by periodic (initially monthly) visual inspections.

Sample Pump

The sample pump is a two-stage positive-displacement type that utilizes a moving diaphragm. During normal operation, the pressure at the pump outlet is set at 4 psi, using the backpressure regulator.

When the enclosure is located a considerable distance from the sample point, restriction on the sample lines may induce a substantial vacuum at the pump inlet. Long sample line runs causes pump inlet vacuum to increase; vacuums greater than 10"Hg are susceptible to leaks and should be routinely checked.

The pump shuts down automatically if the conductivity sensor detects moisture in the sample system tubing downstream of the sample gas cooler. The controller also shuts down the sample pump in the event of a fatal alarm.

Moisture Sensor

The conductivity sensor monitors the sample gas stream at the sample gas cooler outlet to detect any moisture, which could damage the gas analyzers. Any droplet of moisture across the conductivity sensor electrodes stimulates a switch. The moisture sensor then sends a signal to the PLC controller causing an alarm. The moisture sensor is also connected to a relay board that automatically shuts off the sample pump, should moisture be detected downstream of the sample conditioner.

Total Sample Flow Meter

The rotameter indicates the sample total flow rate at the pump outlet. The flow rate should be approximately 5 to 7 liters per minute (l/m), depending on sample line length and sample system vacuum.

Analyzer Flow Meter

Sample gas flow for each analyzer is indicated and controlled by a rotameter. The rotameter flow rate should be approximately 0.5 l/m.

Back Pressure Regulator

The sample gas flows through the total flow meter at a rate of approximately 5-7 l/m. The gas flow then divides and flows through the analyzer sample flow meters. Excess sample gas is vented through a backpressure regulator. Adjust the backpressure regulator to maintain 5-7 l/m.

Analytical Instrumentation

The following sections provide a brief theory of operation overview of the analytical equipment components of the CEMS.

NOx, SO_2, CO, and CO_2 Analyzers

The California Analytical Instruments ZRE analyzer utilizes Non-Dispersive Infrared Radiation (NDIR). It measures these concentrations contained in sampling gas on the principal that different atomic molecules have an absorption spectrum in the wave band of infrared rays, and the intensity of absorption is determined by the Lambert-Beer law.

It uses a single infrared beam that is modulated by a chopper system and passed through a sample cell of predetermined length that contains the gas sample to be analyzed. As the beam passes through the cell, the sample gas absorbs some of its energy. The attenuated beam (transmittance) emerges from the cell and is introduced to the front chamber of a two-chamber, infrared microflow detector. The detector is filled with the gas component of interest and consequently the beam experiences further energy absorption. This absorption process increases the pressure in both chambers.

The differential pressure between the front and rear chamber of the detector causes a slight gas flow between the two chambers. This flow is detected by a mass-flow sensor and converted into an output signal.

O2 Analyzer (Dry Extractive)

The CAI ZRE analyzer also measures the oxygen concentration by utilizing the paramagnetic method of analysis. The operation of the analyzer is based upon the principle of the magneto-dynamic oxygen cell. The paramagnetic susceptibility of oxygen is significantly greater than that of other common gases, and consequently, the molecules of oxygen are attracted much more strongly by a magnetic field than the molecules of the other gases. Most of the other gases are slightly diamagnetic, which mean that their molecules are then repelled by a magnetic field. The principle of the magneto dynamic cell is based upon Faraday's method of determining the magnetic susceptibility of a gas. The cell consists of two nitrogen-filled quartz spheres arranged in the form of a dumbbell that is suspended in a symmetrical non-uniform magnetic field.

When the surrounding gas contains oxygen, the dumbbell spheres are pushed out of the magnetic field by the change in the field that is caused by the relatively strong paramagnetic oxygen. The torque acting on the dumbbell is proportional to the paramagnetic properties of the surrounding gas and, therefore, it can be used as a measure of the oxygen concentration. The distortion of the dumbbell is sensed by a light beam and projected on a mirror attached to the dumbbell whereof it is reflected to a pair of photocells. When both photocells are illuminated equally, the output will be zero. The output from the photocells is connected to an amplifier, which in turn is fed to the feedback coil of the measuring cell. If the oxygen content of the gas sample changes, the corresponding current output of the amplifier, which is proportional to the oxygen content, produces a magnetic field in the feedback coil opposing the forces and thereby causing the dumbbell to rotate.

Since the feedback current from the amplifier is proportional to the oxygen content of the gas sample, the output signals that are produced by the amplifier will be accurate and linear. The paramagnetic susceptibility of oxygen varies inversely as the square of the absolute temperature. To provide compensation for changes in analyzer temperature, a temperature sensitive element in contact with the measuring cell assembly is included in the feedback current circuit.

Wet O2 Analyzer

For the analysis of O_2 wet, an Ametek/Thermox Model WDG Insitu Zirconium Oxide analyzer is installed. It is a multi-range analyzer with the 25% full scale range configured. The analyzer uses a zirconium oxide crystal for the detection of the O_2 molecule. The system requires that the probe with the sensing cell in it, be inserted into the process. The working element of the gas sensor is a closed-end tube made of a ceramic oxide. When it is hot, it becomes a conductor of electricity because of the mobility of the oxygen ions in its crystal structure. Electrodes of porous platinum are coated onto the inside of outside of the cell ad connected to the microprocessor control unit. When the sensing cell is hot, a voltage is produced that is logarithmically proportional to the ratio of the oxygen concentration of the gas on the reference side of the cell (usually ambient air) and the oxygen concentration of the sample. The percent oxygen value will appear on the microprocessor control display. The sensing cell is a partial pressure device and responds directly to changes in sample pressure. Moisture content is calculated with the wet and dry O_2 measurements. The formula used is $(O_2d\text{-}O_2w)/O_2d$.

Dual Pass Opacity Monitor

The Teledyne Monitor Labs Lighthawk 560 dual pass opacity monitor is based on the principle of transmissometry. A light beam with spectral characteristics is projected through the effluent stream of a stack or duct exhausting combustion or process gases. The amount of light reflected back to the instrument from a reflector, after passage through the stream, is compared with the maximum possible return when no effluent is present. The return signal is an indication of the transmittance of the effluent. Particulate matter in the effluent stream attenuates the projected light beam. The opacity of the gas stream is determined by measuring the attenuated signal from the instrument. The opacity is expressed as a percentage.

Dieterich Standard Model 70 Annubar Stack Flow Monitor

For the measurement of flue gas glow in each of the ducts, two gas flow monitors are installed. Each gas flow monitor includes an averaging pitot tube and a thermocouple to measure the delta pressure and temperature of the flue gas. This probe mounts on a 1 ½" close nipple with stainless steel support sleeves. The pitot tube is constructed of Monel and the thermocouple probe is constructed of Hasteloy C-276. These signals are conditioned in the instrument shelter and are transmitted to the PLC. The gas flow monitor can be calibrated directly by built in EPA methodology (Method 2). A periodic backflush of the pressure sensing lines is designed into the system. No plant utilities are required at the probe locations.

In addition to the average delta pressure and temperature, the water content of the flue gas is calculated using the ratio of oxygen measured on a "wet" basis to oxygen measured on a "dry" basis. Certain constants have also been programmed into the PLC and are used in the calculation of the flow value by the PLC. For a complete set of constants and formulas used in the flow calculation, refer to the CiSCO system manual in Appendix C.

The PLC computes a flow value in million standard dry cubic feet per hour (msdcfh) and provides this output to the plant.

CEMS Controller

The CEMS system includes a series of intelligent input and output modules that are also known as a Programmable Logic Controller (PLC). The Allen-Bradley Model Compact Logix PLC modules are packaged for harsh industrial environments and communicate with the DAHS or the plant's DCS. The controller is mounted inside of the gas analyzer cabinet for ease of connection and added protection.

Included in a typical system are analog-to-digital converters that take 4-20 mA signals from the analyzers and convert the signal into digital values. These digitized values are converted into engineering units within the controller. The digital input points are used to detect the presence of status conditions such as in calibration, or analyzer fault. The input points can also be used to detect process conditions such as on/off, startup or shutdown.

The controller can run in a stand-alone mode (i.e., not connected to the DAHS or DCS). The controller continues to check calibration of all analyzers in cases where the DAHS may be temporarily down. In addition, the controller has battery backup memory. Data for each channel can be stored in memory. This ensures that if the DAHS is down for any reason, no data is lost. When the DAHS returns to service, the available data from the controller can be retrieved. The data in the controller is stored on a "first in first out" (FIFO) basis.

The PLC automatically performs a system calibration error check at predetermined intervals to ensure accurate measurements.

Data Acquisition System

The Data Acquisition and Handling System (DAHS) consists of a desktop Dell Model Optiplex 980 computer with a CISCO CeDAR DAHS software package and associated hardware. The PLC sends information to the DAHS via an Ethernet switch. The switch then communicates with the DAHS and the Plant DCS. All data is stored on the computer hard drive as minute averages.

A number of process-operating parameters are monitored by the PLC and logged by the DAHS. These include calibration control, alarms, analyzer status, and process status.

The DAHS provides the functions required to fully meet SCAQMD Rule 218 and 218.1. The system also provides a configurable environment to fulfill all state and local regulations as defined by the site's air permit. Reports may be produced in either hard copy or electronic format.

3 CEMS Startup, Calibration, and Routine Operation

3.1 Introduction

This section contains start-up procedures for the CEMS following a shutdown period. It also contains procedures for a calibration (both automatic and manual modes) to be performed routinely or at operator discretion, to check and assure that the system is operating correctly and with consistent accuracy.

3.2 Safety Checks

Safety awareness of the operational and maintenance aspects of any equipment unit should be inherent in the workplace. Before beginning or restarting operation of any CEMS unit or system, a safety awareness approach calls for a visual check by an operator who is knowledgeable with the system. In general, the lead person responsible for the operation of the emissions monitoring equipment should perform the following checks as detailed in section 8 of this plan.

All personnel must follow the facility's safe work practices, which are incorporated herein by reference.

3.3 Component Check

The operational integrity of the system components is dependent upon the status indicators of the units being fully functional. Before beginning or restarting the system, check that all indicator light bulbs and displays are operational. Check all knobs, dials, rocker switches, etc. to ensure they are in good working order. Check flowmeters for cleanliness and visual clarity, and check tubing for any loose connections or deterioration. Check the calibration gas cylinders to ensure that all connections have been made and are secure. Check cylinder pressures and expiration dates. Be sure that all cylinders are open to supply the required gas.

Personnel who will operate the CEMS should take time to become familiar with the system components. Operator familiarity is necessary to be able to troubleshoot and identify minor problems that can become major and cause the system to be inoperable.

3.4 Temperature Control

Operation of the system components, particularly the electrical and instrumentation units must be in a controlled environment to ensure accurate and reliable operation. The cabinets which house the monitoring equipment are equipped with HVAC systems that will maintain the operating stability and temperature of the instruments. Personnel are required to check the thermostats daily and record on the daily checklist detailed in section 8 of this plan. Desired temperatures of 70°F to 75°F should be maintained even when the equipment is not in operation.

3.5 Power Verification

- Verify that all analyzer power switches and all circuit breakers are turned OFF.
- Verify correct voltage and amperage entering the power distribution panel by comparing with drawings and specifications for this unit.
- Verify proper ground connection at the power distribution panels. Verify shelter ground. Verify plant instrument ground is connected to isolated ground bar.
- Turn on circuit breakers in power distribution panels, one at a time, and verify correct voltage and device operation of each circuit breaker. Turn on all analyzer power switches to verify proper analyzer operation.

3.6 Startup Procedures

The following paragraphs pertain to the start-up of a typical monitoring system after a short shutdown period.

- Allow the sample gas cooler to operate for 30 minutes until proper cooling block temperature is achieved.
- Verify that all calibration gas bottles are open and have over 300 psig (inlet stage of regulator) cylinder pressure.
- Verify that all calibration gas bottles are set to 20-psig outlet pressure.
- Verify that the Main Analysis Enclosure is receiving instrument air at 30 psig.
- Adjust flow to the analyzer to provide approximately 0.5 l/m This will put the flowmeter ball in the midsection of the yellow colored portion of the analyzer flowmeter. Adjust flow to the bypass flowmeter at a rate of 5-7 l/mto ensure acceptable CEMS response time.
- After sample conditioner reaches normal operating temperature (4-5°C, 45°F) place system in normal operating mode.

Warning: Do not flow calibration gas or expect "normal operation" until the sample gas cooler temperature has stabilized.

Normal System Sampling Flow Verification

a. Place system in maintenance mode.

b. Verify probe vacuum gauge reads 0 inches Hg.

c. Verify instrument air pressure gauge reads 30 psig.

d. Adjust the filter regulator until the pressure regulator gauge reads 4 psig. This sets the pressure for probe purging.

e. Place system in automatic operating mode.

f. Adjust the backpressure regulator to allow total flow of 5-7 l/m.

g. Adjust the analyzer rotameter to provide 0.5 l/m.

h. Verify bypass flow rotameter is between 5 and 7 l/m.

i. Verify that vacuum gauge indicates less than 5" Hg.

j. Perform leak check of system. Manually flow Nitrogen (N_2) cylinder gas (zero gas). Verify O_2 analyzer is reading <0.1% O_2. If in-leakage is found, check all vacuum side (upstream of the sample pump) fittings for tightness and serviceability. If the O2 value is still reading <0.1%, inject N_2 at the inlet side of each component in the sample stream in order up to the inlet of the pump. Do this with an overflow "T" with one port of the "T" open to atmosphere and a slight positive pressure of N_2 at that open port. When the analyzer reading indicates <0.1% it will prove all components and connections downstream of the injection point.

System sampling has now been verified and the CEMS should operate automatically.

3.7 Automatic Operation

The CEMS is designed to operate automatically with little operator attention. However, to assure optimal performance, follow the maintenance schedule in Chapter 7 and the routine operation procedures described below.

Perform the following procedures at least once per week to ensure accurate and reliable measurement.

1. Check flow rate of all rotameters. Verify mid-scale readings, adjust if necessary. Large variations from required settings indicate a need for maintenance.
2. Check sample pressure. Verify pressure gauge reads at least 5 psig. Large variations from the required settings indicate a need for maintenance.
3. Check sample vacuum. The sample vacuum is not adjustable and is only an indication of the condition of upstream components. As the vacuum reads higher, that is an indication of probe or sample line restriction; it should be checked.
4. Verify that the sample conditioning unit is operating properly. Check temperature LED (if so equipped) or temperature alarm light.

3.8 24-Hour Calibration Error Test

A Calibration Error (CE) Test is performed automatically by the PLC once every 24 hours. When the controller starts the automatic calibration sequence, the automatic sampling sequence is suspended and reset. Certified calibration gases are routed up through the sample line to the probe and back down the normal extraction gas sample path to the analyzers. The sequence in which the analyzers calibration error is audited is determined by the CEMS programmer. More than one analyzer may be tested simultaneously.

The CE test is divided into several sequential events. During the CE test, the PLC energizes the solenoid valves to allow calibration gas to flow to the sample probe and on to the instruments. The time internals for purging and flowing of calibration gases can be altered to match the CEMS response time and depends partly on the length of the sample line.

Calibration Gas 1 flows for a preset time interval. Then the PLC energizes Calibration Gas 2 and so forth until all appropriate gas bottles have been selected. Upon completion of the CE test the PLC resets the automatic calibration sequence and resumes normal automatic sampling.

A failed CE test is indicated when excessive drift in any analyzer is detected. The operator can use the PLC operator interface terminal (OIT) to manually initiate a CE test at any time. A manually initiated CE test will be performed after any maintenance has been completed.

To check the system out after any maintenance activities, start by performing a sample system bias adjustment. This will be done before taking the system out of maintenance mode. Record the system pressure that is showing prior to performing the sample system bias. To perform a sample system bias adjustment start by manually flowing zero gas directly to the analyzer (local calibration) and while flowing, use the regulator to adjust the sample pressure to exactly what the normal sampling mode pressure had been. Adjust the zero and spans on all of the analyzers and shut off all gases. Return the system for a remote (at-the-probe) CE test. Manually flow calibration gas again through the whole system and check that the readings are close to the same. Any significant difference in the readings shows that the system is leaking in ambient air, calibration gases, or stack gas into the system. If leaking, check all fittings, sample system components upstream of the pump and cal gas solenoid valves and repeat the above procedure.

Place the system back into normal sample mode.

4 Data Recording and Reporting

4.1 DAHS Procedures and Reports

The CEMS data acquisition and reporting is controlled by a Data Acquisition and Handling System (DAHS). The DAHS provides automated data monitoring and management capabilities to the CEMS using CISCO CeDAR software on a Windows platform. The DAHS facilitates all of the data reporting requirements necessary to establish compliance with EPA, state, and SCAQMD operating permit emission limits.

The CEMS has a Programmable Logic Controller (PLC). The PLC transmits data from the analyzers to the DAHS. The DAHS polls the PLC for data to generate and stores 1- and 15-minute averages.

Analog signals of emission parameters are converted by the DAHS into emission measurement values in engineering units. After conversion of the signals, pollutant/diluent parameter values are calculated to reporting units of emission limits. Depending on required report format, reporting units may be expressed as calculated values or raw engineering units.

The DAHS indicates any occurrence of specification limit exceedances or CEMS operational problems. In the DAHS, necessary reports are generated in the required format for submittal to the applicable regulatory agencies.

Alarm reports are generated by the DAHS to call operator attention to excess emissions and system problems. Alarms and messages are triggered by analog and status signals to the DAHS and, in some cases, by operator entry via the PC keyboard. The DAHS records an alarm message at the time of the alarm to provide a real-time mechanism for alerting operating personnel to excess emissions and monitoring system problems. When alarm messages are received, appropriate technicians are notified and troubleshooting, maintenance and corrective actions are initiated. The alarm message provides for automated and also manually entered documentation of the CEMS or turbine operating status during alarm conditions.

Data compiled by the DAHS include analyzer values, hourly averages, excess emissions, calibration data, alarm messages, reason codes, corrective action codes, and process data. The DAHS generates several reports which serve as the primary basis and substance of quarterly emission reports required under EPA and state regulations.

A partial listing of the reports that may be generated from the DAHS is provided as follows.

- Pollutant Emissions Reports
- Alarm reports
- Calibration Reports
- Operator Log Reports

- System Event/Status Reports
- Quarterly Summaries

Refer to the DAHS software user manual for system details and report generation procedures.

In addition, hard- and electronic-copy CEMS files are maintained at the facility. The files contains QAP check forms, audit results, corrective action forms, and calibration gas certificates of analysis.

Maintenance personnel maintain a handwritten CEMS log and enter descriptions of preventive and remedial actions performed on the monitoring system components. This record is also used to document the use of spare parts. A periodic review of the CEMS maintenance log provides a guide to possible problem trends with the CEMS and input as to the needs of the spare parts inventory.

4.2 Data Acquisition and Validation

All emissions be reduced to one-hour time-based emissions. The following defines the basis for measuring and collecting data.

1. The CEMS must complete a minimum of one cycle of operation (that is, sampling, analyzing, and data recording) for each successive 15-minute period.
2. A valid hour (clock hour) of data is computed from at least one valid data point in each 15-minute quadrant of the hour in which the unit operates. Emissions data are reduced and recorded as one-hour averages.

For partial operating hours (any clock hour with less than 60 minutes of unit operating time) at least one valid data point in each 15 minute quadrant of the hour in which the unit operates is required for calculating an hourly average.

For an operating hour in which maintenance or QA activities (CDC, CGA) are performed:

a. If the unit operates in two or more quadrants of the hour, a minimum of two valid data points separated by at least 15 minutes is required to calculate the hourly average.

b. If the unit operates in only one quadrant of the hour, at least one valid data point is required to calculate the hourly average.

For full or partial operating hours, all available valid data points will be used to calculate the hourly average.

Data recorded during periods of system breakdown, repair, CE tests, and zero and span adjustments are not be included in the data averages.

The CEMS will record data during all periods of operation of the monitored unit including periods of startup, shutdown, malfunction or emergency conditions, except for CEMS breakdowns, repairs, calibration checks, and zero and span adjustments.

If a CE test fails during any operating hour, all data for that hour will be invalidated, unless a subsequent calibration check is performed and passed in the same hour, based on valid data recorded after the successful calibration.

Data considered to be invalid are not used in calculating compliance nor counted toward meeting minimum data availability. Periods of invalid hourly data are logged on the quarterly data summary.

If an Out-of-Control event occurs, the data collected is considered invalid from the time of the previous assessment (CE, CGA, or annual assessment) to the time the Out-of-Control condition occurred. The data remains invalid until the appropriate maintenance and corrective action(s) are performed and the assessment repeated and parameters have returned to normal for the affected monitor.

5 Quality Control Activities

5.1 Introduction

Quality Control (QC) is the procedures, policies, and corrective actions necessary to ensure product quality. QC procedures are routine activities. These activities include but are not limited to daily calibrations and routine maintenance.

Quality control activities range from the correct installation of the CEMS to proper data handling procedures. Proper performance of the routine quality control procedures is dependent upon the use of qualified and well-trained staff. Facility personnel strive to keep the CEMS in proper operation at a minimum of 95% of facility operating time.

5.2 Calibration and Audit Gases

Calibration gases are used to verify the accuracy of the gas analyzers. Daily calibration gases are used to verify that the instruments are within the allowable error limits for a two-point (zero or low span and high span) on a daily basis. Cylinder Gas Audit (CGA) gases are used to verify that the instruments are within the allowable limits for a two-point calibration (low span and mid span) on a quarterly basis.

The gas cylinders are 2000 psig and must be changed at 150 psig (EPA specifies 100 psig) to maintain correct gas concentrations. Cylinder regulators are set to between 15 and 20 psig. Calibration gases should be reordered when the bottle pressure drops to 1000 psig.

Gas cylinder pressures are checked on a daily basis. Calibration gas can be lost if the cylinder pressure is set too high (lifting the seat on the normally closed solenoid valve that controls gas flow), through leaking fittings, and through a leaking solenoid valve. Brass pressure regulators should be used only on cylinders containing CO_2 or N_2. Stainless steel regulators must be used on cylinders containing NO_X and SO_2.

The cylinders will contain a known concentration of a single gas such as N_2 (used for zero or low span calibration), or blended gases such as CO_2, NO_X, SO_2, and N_2 (used for high span calibration). Refer to the manufacturer's certification sheet provided with each cylinder for the gas concentration, cylinder certification number and EPA Protocol statement. Even though the cylinders usually have a tag listing the gas concentrations, always use the values on the certification sheet for entry into the DAHS. Also, record cylinder changes, gas concentrations, expiration date, and certification numbers in the CEMS maintenance log. Keep a copy of the certification sheet as part of the site records.

Though unlikely, it is possible for EPA Protocol gas cylinders to be in error. If an analyzer shows excessive drift after changing a cylinder, check the analyzer with the cylinder that was replaced, or another cylinder that is known to be accurate. Also, make sure the new gas values were entered correctly in the DAHS. If a cylinder is suspect, return it to the supplier or have it re-certified at an independent testing lab.

Daily Calibration Gases

Specific to the application, the monitoring system is connected to a required number of calibration gas bottles. The CEMS controller will automatically perform CE tests daily. Storage of gas bottles requires a secure and safe installation (as defined by federal and state regulations). The calibration gases normally utilized are of the same gas being measured by the CEMS. Daily calibration gases need not be EPA Protocol certified.

Zero air material (used in daily calibrations) is defined as:

1. A calibration gas certified by the gas vendor not to contain concentrations of SO_2, NO_X, or total hydrocarbons (THCs) above 0.1 ppm, a CO concentration above 1 ppm, or a CO_2 concentration above 400 ppm (the DVP system utilizes this option for zero air).
2. Ambient air conditioned and purified by a CEMS for which the CEMS manufacturer or vendor certifies that the CEMS model produces conditioned gases that does not contain concentrations of SO_2, NO_X, or THCs above 0.1 ppm, a CO concentration above 1 ppm, or a CO_2 concentration above 400 ppm.
3. A multi-component mixture certified by the supplier of the mixture that the concentration of the component being zeroed is less than or equal to the conditions specified in 1 above and that the mixtures' other components do not interfere with the CEMS readings.

Quarterly Cylinder Gas Audit Gases

A CGA must be performed and documented on a quarterly basis as specified for the application. CGA calibration gases must be certified by comparison to NIST gaseous Standard Reference Materials (SRM's) or NIST/EPA approved gas manufacturers' Certified Reference Materials (CRM's) following EPA Traceability Protocol No. 1.

5.3 Safety Procedures for High Pressure Gas Cylinders

1. Avoid rough handling of cylinders. Do not drop them or allow them to strike each other.
2. The cylinders should always be secured in an approved rack system whenever the bottles are not being used.
3. Whenever possible, store cylinders in a dry enclosure to protect them from extremes of weather and ground moisture. Do not subject cylinders to temperatures higher than 125°F. Storage of calibration gas bottles requires a secure and safe installation as defined by federal and state regulations.
4. Do not allow any part of the cylinder to come in contact with an open flame. Do not allow an arc of an electric arc welder to strike any part of the gas cylinder.
5. Do not remove the valve protection cap until the cylinder has been secured and is ready for use. Do not tamper with any part of the cylinder valve.

6. Use a hand-truck to move cylinders, even for a short distance. Do not drag, roll or slide cylinders.
7. Do not place a cylinder where it may become part of an electric circuit.
8. Per the EPA, **a compressed gas calibration standard should not be used when its gas pressure is below 1.03 megapascals (150 psig)**. NIST has found that some gas mixtures have exhibited a concentration change when the cylinder pressure has fallen below this value.
9. Do not store full and empty cylinders together.
10. Do not tamper with any part of the cylinder valve.

5.4 Calibration Gas Pressure Regulator Purging

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In order to maintain cylinder integrity and obtain the best results possible, the end user should purge all regulators. What happens to the gas between the cylinder and its end use is controlled by the quality of the connecting lines and the purging procedure.

Purging of regulators is often not done at all, or is done by simply by allowing an arbitrary amount of gas to flow through the regulator. There is a shortcoming to this method, however. In virtually all regulators, there are internal “dead” pockets that tend to hold contaminants. Just as a smoke detector in a house cannot function if it is installed too close to the junction of wall and ceiling, the internal “dead” pockets in a regulator tend to be unaffected by the flow of purge gas. Better results will be achieved by alternately pressurizing and depressurizing the regulator with the purge gas. This is called dilution purging.

How to Perform Dilution Purging

The most effective means of purging regulators and connecting lines is the dilution purging method.

1. Attach the regulator to the specialty gas cylinder. A tee with a valve on the side branch should then be located in the line between the regulator and the instrument(s). This branch should be connected to a safety vent while the main trunk runs to the instrument(s). The tee should be located close to the instrument so that the connecting line between the regulator and instrument is also purged.
2. Turn the regulator adjustment to the fully closed position. Then, close the safety vent valve and the valve at the instrument and open the valve on the outlet side of the regulator.
3. Open and quickly close the cylinder valve to pressurize the inlet side of the regulator to cylinder pressure. It is necessary to quickly close the cylinder valve after each cycle to keep downstream contaminants from entering the cylinder until the

regulator is fully purged. Mounting the regulator on a single-station manifold that incorporates a check valve in the pigtail will eliminate this problem.

4. Turn the regulator adjustment to establish an appropriate delivery pressure and open the vent valve to bleed off the regulator pressure.

Steps two through four represent one purge cycle. This cycle should be repeated three to four times to ensure that the regulator and connecting line are both properly purged.

5.5 Calibration Gas Cylinder Change Out

To ensure successful CE tests, it is critical that the calibration gases be checked daily and replaced when low. Also periodically check expiration dates posted on the bottle certificate. Do not use calibration gases that have passed their expiration dates. Always order new calibration gas bottles well before needed. The lead time for ordering and having bottles shipped to the plant can be more than 3 weeks.

Using a gas cylinder whose contents are too low causes the gas certification to be invalid, thereby invalidating the calibration. The EPA specifies that a bottle should be changed out whenever the bottle pressure drops below 100 psig. The bottle should be changed out whenever the pressure drops to 150-200 psig. Laboratory tests have indicated that a concentration shift away from the certified value can occur when the bottle pressure drops below 100 psig.

Use the following procedure as a general guide for replacing gas cylinder bottles.

1. Turn off the regulator for that cylinder and close the valve. Uncouple the hose from the cylinder, making sure there are no leaks from the cylinder.
2. Transport the empty cylinder to the designated pickup area for shipment back to the vendor. B e sure to replace the chain on the cylinder rack when done. Tear off the “In Service” segment of the stock tag, leaving the “Empty” segment attached.
3. Select a new cylinder from the full racks. Ensure that the new bottle is within the correct percent of span specification required for the analyzer and type of test (daily calibration or quarterly audit).
4. Install the new cylinder making sure the strap is secured around the cylinder. When connecting cylinders, be sure not to over-tighten and flatten the white seal inside the regulator connection. If this is damaged, replace it. Check for leaks on all connections using soap solution. Tear off the “Full” segment of the stock tag, leaving the “In Service” and “Empty” segments attached.
5. Enter the new cylinder value into the DAHS and save the change. Also enter the new value into the analyzer using the analyzer’s front panel control menu.
6. Put the system into maintenance request mode and manually flow gas to the analyzer to ensure that the sampling system is processing the new cylinder. Re-zero

and re-span the analyzer at this time if needed. Remove the system from maintenance request mode.

7. Perform a full, hands-off calibration in accordance with the regulations and check the results.
8. Check the cylinder out of stock so that proper stocking levels can be maintained.
9. Make an entry in the CEMS maintenance log book that the cylinder was changed, recording the old cylinder number and values and the new cylinder number and values. Note in the log book that a passing calibration was performed with the new bottle.

5.6 Daily Requirements

The following checks and audits are to be performed any day that the process combusts any fuel or at any time emissions pass through the stack. The daily audits should also include an inspection of the data recording system, an inspection of the control panel and/or DAHS warning lights, an inspection of the sample transport and interface system (example: flowmeters, filters), and inspection of the calibration gas cylinder supplies. Use the preventive maintenance check sheets located in Chapter 7 of this QAP to check and record system values on a daily basis.

Daily Operator System Check

A daily operator system check will be performed on any day that the process combusts any fuel or at any time emissions pass through the stack. The daily system check will include an inspection of the data recording system, the control panel and/or DAHS warning lights, the sample transport and interface system (e.g., flow meters, filters), the calibration gas cylinder supplies, and a review of the daily calibrations and data reports.

Any maintenance activity performed during the day will be documented in the CEMS maintenance log files. Operators will watch for non-compliance/exceedance episodes and immediately report any incidents to the appropriate personnel and initiate corrective action procedures.

Calibration Error Test (CE Test)

Source owners and operators of the CEMS must check, record, and quantify the Calibration Drift (CE) of each monitor at least once daily. The CE test, to the extent practicable, must be performed approximately 24 hours apart.

For dual span or auto ranging monitors the calibration drift test must be performed on each range (low and high) used since the previous calibration drift test.

An automatic calibration sequence is initiated approximately every 24 hours. During a calibration, the system controller energizes normally closed solenoid valves to allow the calibration gases to flow. The gases flow from the gas cylinders to the sample interface enclosure at the probe, and then back to the analyzers. The daily calibration sequence uses both a high level (span) gas and a low level (zero) gas. Manual override is also an option.

Calibration gases flow through the sample tubing and all system components, to simulate, as closely as possible, the path the flue gas will travel. Each gas flows for a pre-determined interval. The first minutes are used for system stabilization. During the last minute, the analyzer response is interrogated by the PLC/controller. The controller passes the response to the DAHS.

The DAHS compares the actual analyzer reading with the expected value of the calibration gas. If the analyzer error exceeds the specification limits, the failure is indicated on the calibration report. When the daily calibration exceeds the specification limits, this indicates a need for corrective actions. Corrective actions may include a manual calibration adjustment of the failed analyzer.

The calibration drift tests will be performed at two concentrations:

1. Zero Level (0-20% of span)
2. High Level (80-100% of span)

Daily calibration gas concentrations need not be certified. The calibration gas will be introduced at the gas injection port.

Additional Calibration Error Tests and Adjustments

Additional calibration error testing is performed:

- Whenever a daily calibration error test fails as described above;
- Whenever a monitoring system is returned to service after repair or corrective maintenance that could affect the monitor's ability to measure and record emissions data; and
- After making certain routine calibration adjustments described below.

Except for the routine calibration adjustments described below, data from the monitor are considered invalid until successful completion of a calibration error test.

Routine calibration adjustments are permitted after any successful calibration error test. These routine adjustments can be done to bring monitor readings as close as possible to the calibration-gas reference values. An additional calibration error test is required following routine calibration adjustments when the monitor's calibration has been physically adjusted (i.e., by turning a potentiometer) to verify that the adjustments have been done correctly. An additional calibration error test is not required if the routine calibration adjustments are made by means of a mathematical algorithm programmed into the data acquisition system.

Additional (non-routine) calibration adjustments of a monitor are permitted before (but not during) CGA checks and RATAs.

Calibration Error Test Equations

Calibration error equations are shown in the table below.

CEMS Calibration Drift Equations
Calibration Drift Equation for Pollutants
$$CD = \frac{R - A}{S} \times 100$$ where: CD = calibration drift as a % of instrument span; R = zero or high-level calibration gas value in ppm; A = actual analyzer response to calibration gas in ppm; S = span of the instrument

Re-calibration Limits

The calibration may be adjusted whenever the daily calibration error (zero or span) is between 2.5% and 5% for all analyzers. After any adjustments are made the calibration error test will be repeated to ensure that the corrective actions were effective.

Out-of-Control Limits

When the CE (zero and span) result exceeds 5% error the analyzer is considered Out-of-Control.

The Out-of-Control period begins with the hour of the failed CE test and ends with the hour of the next satisfactory CE test after corrective action.

Whenever a failed calibration, corrective action, and a successful re-calibration occur in the same hour, the system will not be considered to be Out-of-Control if two or more valid data points from that hour were recorded.

The DAHS records the CE test results and "flags" the calibration report if the recalibration (or out-of-control) criteria are exceeded. Recalibration or corrective action is taken when the failure is identified.

During the period the CEMS is Out-of-Control; the CEMS data may not be used in calculating emission compliance nor be counted toward meeting minimum data availability. However, the invalid data is not deleted or excluded from the records or database.

5.7 Data Recording and Written Records

Record and tabulate all calibration-error test data according to month, day, clock-hour, and magnitude in ppm or percent volume, (as applicable to individual applications). For analyzers that automatically adjust data to the corrected calibration values either record the unadjusted concentrations measured in the calibration error test prior to resetting the calibration or the magnitude of any adjustment.

All measurements from the CEMS must be retained on file for a minimum of five years. However, emission data obtained while the CEMS is Out-of-Control may not be included as part of the minimum daily data requirement, neither can the data be used for calculation of reported emissions for that period.

6 Quarterly Quality Assurance Activities

6.1 Introduction

Quality Assurance (QA) is a series of checks performed to ensure the QC procedures are functioning properly. The activities include but are not limited to quarterly and annual audits.

6.2 Quarterly Assessment – Cylinder Gas Audit

The following assessments will be performed during each calendar quarter that the unit combusts fuel but in no more than three quarters in succession. This requirement is in effect the calendar quarter following the calendar quarter in which the monitor or CEMS is certified. SCAQMD Rule 218.1 (b)(4)(D) specifically requires that the CGA be conducted according to the provisions of 40 CFR 60, Appendix F.

The Cylinder Gas Audit (CGA) is performed for each monitor at least once during each unit operating quarter based on the requirements of 40 CFR 60, Appendix F, but in no more than three quarters in succession. During the fourth quarter, the accuracy of the CEMS is evaluated by conducting a Relative Accuracy Test Audit (see Annual Assessments). If applicable, the CGA is performed on both the low and high ranges. Use separate calibration gas cylinders for each concentration during the audit. Conduct the CGA no less than 60 days apart.

Cylinder Gas Audit Procedure

Connect all audit gas cylinders to the proper transport lines. Use EPA Protocol certified gases. Ensure that each audit gas has at least 700 psi (in accordance with US EPA field manual).

Challenge the CEMS with an audit gas of known concentration at two points within the following ranges:

	Audit range		
		Diluent monitors for—	
Audit point	**Pollutant monitors**	**CO_2**	**O_2**
1	20 to 30% of span value	5 to 8% by volume	4 to 6% by volume.
2	50 to 60% of span value	10 to 14% by volume	8 to 12% by volume.

Challenge the CEMS three times at each audit point and use the average of the three responses in determining accuracy. Do not use an individual gas concentration consecutively. Instead, alternate between the two audit values. Use the average of the three responses for each audit point in determining accuracy. The monitor should be challenged at each audit point for a sufficient time to assure that any absorption-desorption phenomena at the CEMS sample transport surfaces have stabilized. The injection time should also take into account the response time of the analyzers and sample system.

Operate each monitor in its normal sampling mode, that is, pass the audit gas through all filters, scrubbers, conditioners, and other monitor components used during normal sampling, and through as much of the sampling probe as is practical. At a minimum, the audit gas should be introduced at the connection between the probe and sample line.

The difference between the actual concentration of the audit gas and the concentration indicated by the monitor will determine the accuracy of the CEMS.

Important: All calibration gases used for CGA testing must be EPA Protocol gases. Do not use gas cylinders if the pressure has fallen below 150 psig. A concentration change shift away from the certified tag value can occur in bottles with low pressures that will have an adverse affect test results.

Protocol gas bottle set up procedure:

1. Shut off CE bottle valves.
2. Make sure protocol gas bottles are hooked up and all lines are secured (no leaks).
3. Open valves on protocol bottles and check bottle pressures. Pressures must be greater than 150 psi.
4. Challenge each analyzer with an audit gas of known concentration at two points for pollutant and diluent analyzers within the concentration ranges shown in the table above.

CEMS Cylinder Gas Audit Equation

Accuracy Equation

$$A = \frac{C_m - C_a}{C_a} \times 100$$

where:

A = accuracy of the CEMS in %

C_m = average analyzer response to the specific audit gas (high or low) in units of concentration

C_a = certified value of audit gas (per EPA Protocol cert.) in units of concentration

Out-of-Control Period

An Out-of-Control period occurs when the CGA exceeds the applicable specifications (> 15% error or 5 ppm difference). The Out-of-Control period begins with the hour of the failed CGA and ends with the hour of a satisfactory CGA following the corrective action.

During the time the CEMS is Out-of-Control the CEMS data may not be used in calculating emission compliance nor be counted toward meeting minimum data availability.

6.3 Annual Assessments:

Relative Accuracy Test Audit

Conduct a relative accuracy test audit (RATA) at least once per year in accordance with the requirements of SCAQMD Rule 218.1 by a testing firm approved under the SCAQMD's Laboratory Approval Program (LAP). Unless an earlier approved protocol is used (i.e., if there are no changes to the equipment, process, or testing contractor) a proposed protocol will be submitted to SCAQMD for approval at least 30 days prior to the proposed test date. Results will be submitted in written form to the District within 45 days after the test.

Prior to the RATA ensure that all preventive maintenance has been performed on the CEMS equipment.

For each RATA test run, the measurements from the monitors will be compared against the corresponding reference method values. The paired data will be tabulated in a table and relative accuracy results calculated.

A minimum of nine sets of paired monitor data and reference method test data will be performed. More than nine sets of paired data may be collected. If done, a maximum of three sets of test results may be rejected, as long as the total number of test results is greater than or equal to nine. All data, including any rejected paired runs will be reported.

Complete each relative accuracy test audit within a 7-day period while the unit is combusting its primary fuel and operating at more than 50% of normal load.

The test shall be completed annually no later than the end of the calendar quarter in which the date of the original certification test was performed. During any relative accuracy tests after CEMS certification, the owner or operator may request a waiver from stratification, cyclonic flow, and/or interference requirements in SCAQMD Rule 218.1 (b)(3)(C), (D) and (E), respectively, by submitting to the Executive Officer, for approval, any applicable documentation or previous test or historical data that meets the stratification, cyclonic flow, and/or interference requirements.

The CEMS shall meet the following RA performance specifications:

- Less than or equal to 20.0 percent of the mean value of the reference method for pollutant concentrations, or the de minimus concentration as follows, whichever is greater:

Pollutant	De minimus Concentration
Nox	1.0 ppm
SO2	2.0 ppm
CO	2.0 ppm
Reduced Sulfur Compounds	4.0 ppm

- Less than or equal to 10.0 percent of the mean value of the reference method for diluents concentrations, or the de minimus value of 1.0 percent O_2, whichever is greater.
- Less than or equal to 15.0 percent of the mean value of the reference method for flow monitors, or the de minimus value equivalent to a calculated volumetric flow rate based on 2 feet per second stack gas velocity for cases where the mean stack gas velocity obtained by the reference method test is less than 15 feet per second.
- Less than or equal to 20.0 percent of the mean value of the reference method for mass emission rates, or the de minimus value equivalent to a calculated mass emission rate based on 2 feet per second stack gas velocity for cases where the mean stack gas velocity obtained by the reference method test is less than 15 feet per second. The relative accuracy requirement may be met if the average of the differences between the CEMS measured data and the reference method test data plus the confidence coefficient is less than or equal to the relative accuracy de minimus value.

Out-of-Control Period

An out-of-control period occurs when any of the above conditions are not met.

The out-of-control period begins with the hour of completion of the first failed RATA and is over at the end of the hour of a passing RATA.

During the period the CEMS is out-of-control the CEMS data may not be used in calculating emission compliance nor counted toward meeting minimum data availability.

Sample System Bias Test

A sample system bias test of the site CEMS is performed annually in conjunction with the RATA. The SCAQMD method 100.1 definition of the system bias is the difference between the gas concentrations exhibited by the CEMS when a calibration gas is introduced as close the sampling probe inlet as practicable, and when the same calibration gas is introduced directly to the analyzer. It is recommended that this test be performed prior to initiation of the RATA test.

To perform the system bias test perform a calibration error test without adjustment as normal. Upon completion of the CE test select a local/direct flow of the calibration gases via the front panel switches directly to the analyzer. Once the switches have been set correctly for system bias, initiate a calibration error test without adjustment. Compare the two reports. The CEMS system bias shall not exceed $\pm$ 5.0 percent of the full span range for contaminant analyzers. Take corrective action if bias exceeds $\pm$ 5.0 percent.

NO_2 to NO Converter Efficiency Verification

A NO_2 to NO converter in a NOx CEMS is the portion of the system that converts nitrogen dioxide (NO_2) in the sample gas to nitric oxide (NO). A low temperature (350 degrees C) molybdenum converter should be used when NH3 is present. Although only required during initial certification testing by SCAQMD Rule 218.1, SCAQMD Source Testing has requested that a procedure be inserted into the QA/QC Plan for Desert View Power to be performed annually in conjunction with the RATA test.

SCAQMD Rule 218.1 (d)(5) states that the test shall be conducted according to the requirements of District Method 100.1 being that the results of the efficiency test must show the converter to be 90% efficient. SCAQMD Rule 218.1 (d)(5) also states that the value for the NO2 gas shall be greater than or equal to the maximum expected or recorded NO2 and greater than or equal to 20 percent of the Full Span Range.

Subsequent to a passing CE test, flow the prescribed NO_2 gas directly to the inlet of the NO_2 converter and allow sufficient time for the NOx analyzer readings to stabilize.

Using the equation CE% = [(R-A)/R] x 100 -100, where R= certified NO_2 cylinder gas value, A = analyzer readings, and CE% = converter efficiency determine if the converter efficiency is greater than 90%. A result of less than 90% triggers corrective action.

7 Routine Preventive Maintenance

7.1 Introduction

According to SCAQMD Rule 218.1, the facility must maintain the CEMS in proper operating condition and a schedule for these procedures to ensure that the CEMS generates, collects and reports valid data that is precise, accurate, complete, and of a quality that meets the requirements, performance specifications, and standards of Rules 218 and 218.1.

7.2 Frequency of Checks

The following sections describe a process of checks that must be followed to ensure reported data is reliable and the CEMS operates dependably. The following includes information about when checks and audits should be performed and when a situation indicates the need for corrective actions. It is essential the personnel conducting the checks and audits completely fill out every item on the appropriate forms. This includes the recording of any comments concerning the condition of the CEMS. Corrective actions should be initiated immediately upon identification of a problem or malfunction.

It is require that zero and span calibration error tests be conducted immediately prior to any maintenance and again after any maintenance. If the post-maintenance zero or calibration drift test shows excessive drift, correction action and recalibration must be conducted to bring the CEMS and its components within specifications. All corrective action activities must be documented In the CEMs log-book.

7.3 Corrective Actions Requiring Recertification

Essentially any change, other than routine maintenance or quality assurance activities, that affects the monitors measuring systems or analysis systems in such a way that measurements or calibrations have changed significantly, triggers a recertification.

The following are examples of situations that require recertification. These changes include, but are not limited to:

- Changes in gas cells
- Path lengths
- Sample probe
- System optics
- Replacement of analytical methods (including the analyzer(s), monitor(s))
- Change in location or orientation of the sampling probe or site
- Rebuilding of the analyzer or all monitoring system equipment

These changes may require EPA notification and recertification. Replacement of analyzers in total will require recertification unless the analyzer was previously certified as a backup for a given CEM.

Recertification of the CEMS may also be triggered if the facility makes a replacement, modification, or change to the flue gas handling system or the unit operation that significantly changes the flow or concentration profile of the monitored emissions.

For recertification testing, the facility shall re-perform all initial certification tests as outlined in the site's original certification test protocol (located under separate cover), as approved by the local Administrator. Approval and notice of recertification test dates must be obtained by petition or may be provided in written guidance from the Administrator.

7.4 Logbook

A logbook will be kept and maintained to track all scheduled and unscheduled maintenance, calibration-gas bottle pressures and any other anomalies or information relevant to the history of the individual CEMS. This will also serve as a record of maintenance performed to manufacturers' instructions for warranty purposes.

A record of all testing, maintenance, or repair activities performed on any monitoring system or component will be maintained in a location and format suitable for inspection. The logbook will include entries for:

1. Any testing, adjustment, repair, replacement, or preventive maintenance action performed on any monitoring system.
2. Corrective actions associated with a monitor's outage period.
3. Any adjustment that re-characterizes a system's ability to record and report emissions data must be recorded (for example, changing of temperature and pressure coefficients).
4. The procedures used to make the adjustment(s).
5. Individual entries must include the date, time and description of corrective and preventive maintenance procedures performed on each CEMS.

7.5 Minimize Time in Maintenance Mode

The goal of this section is to minimize downtime and the impact on data availability during normal routine maintenance. Following the steps on routine preventative maintenance as well as any additional maintenance requirements on all equipment supplied with this system will greatly reduce emergency or breakdown repairs. All necessary spare parts, tools, and equipment should be available to the persons responsible for the upkeep of this system at all times. This is critical to plant owners and operators as too much time spent in downtime can affect data availability requirements.

All maintenance activities, whether routine or non-routine, needs to be documented by date, time, type of activity or corrective action, name of technician performing the checks, total time needed to complete the check, and the results of the post-maintenance required compliance check. This information to be logged in the appropriate CEMS logbook and/or maintenance-check forms.

Some maintenance can be performed while the CEMS is operating, without effecting data integrity or system availability. Much of the CEMS servicing requires placing the system in maintenance mode to perform the work. A way to minimize downtime is to take advantage of planned or unplanned turbine trips, outages or overhauls. Maintain the DAHS in operational status at all times.

If the system is equipped with a back-up CEMS then perform service, calibration and a complete function and accuracy check of the back-up system before transferring the data-recording task to the back-up system. Ensure that the back-up CEMS is accurately analyzing, recording and reporting data before beginning the maintenance or repairs on the primary unit.

Hourly emission averages will be affected by spending excessive amounts of time in maintenance mode. This in turn affects data availability. Leave the system in maintenance mode for only as long as needed to perform the needed maintenance or repair activity. Return the system to normal sampling mode as soon as possible.

Frequency of maintenance depends on many variables such as geographic location (humidity and seasonal temperature fluctuations), fuel type, stack temperature and moisture content, etc. Consequently, scheduled maintenance intervals will vary from the general guidelines given in the CEMS Operation and Maintenance (O&M) manual and the individual component equipment manuals.

7.6 System Checks

The following sections provide a brief overview on general system checks used for troubleshooting proposes.

Calibration Failure

Technicians are responsible for checking the daily calibration report as soon as the calibration sequence has been completed for the day. Calibration results are reviewed through the DAHS and can be printed out. If a calibration failure occurs, data is considered out-of-control until a successful re-calibration has been performed and passed.

If a calibration failure occurs, first check the gauge on the related calibration gas cylinder to see if the pressure is adequate (above 150 psig). If the gas pressure is adequate, manually perform a calibration. If calibration cannot be successfully completed by adjusting the analyzers, troubleshoot and perform maintenance as required on the analyzer.

Use the following as a guideline for performing troubleshooting after a calibration failure:

1. First check the value entered in the DAHS and the analyzer for the gas cylinder to that listed on the cylinder label. If the values do not agree, correct.
2. Next, check to see that the bottle supply valves are open, that the pressure regulator is set to 40 psig, and that the cylinder has more than 150 psig of gas remaining. If the cylinder level falls below 150 psig, the cylinder will need replacing.
3. If the calibration failure percentage is large, this may indicate a system or component failure in the analyzer; not simply analyzer drift. In this situation, follow the troubleshooting procedures detailed in the equipment manufacturers' manuals.
4. If the cylinder and the analyzer are set up correctly, and if the failure percentage is small, the analyzer should be re-zeroed and re-spanned following manufacturers' procedures.
5. All analyzer adjustments must be followed by a hands-off, full system calibration.
6. Check the calibration report to show that the adjustment or repair resulted in a passed calibration and that the out-of-control period has ended.
7. Log the corrective actions taken in the CEMS maintenance log book. Be sure to include:
    a. Date and time analyzer became out of control or out of service.
    b. Description of any testing, adjustment, repair, component replacement, or preventive maintenance performed.
    c. Analyzer readings before and after the adjustment.
    d. The follow up quality assurance activity that was performed to show that the adjustment or repair involved solved the problem (minimum, hands off calibration check).
    e. Date and time the analyzer was returned to service.

Excessive Zero Drift

If a calibration failure requires a substantial readjustment of the zero calibration on an analyzer, and if subsequent automatic calibration indicates a widely drifting zero output, troubleshoot and service that analyzer following the procedures in the manufacturer's instruction manual.

Abnormal Measurement Output Voltage/Current

If output voltage/current range is not between the required range for each analyzer and calibration is completed successfully, refer to the analyzer manufacturer's instruction manuals for adjustment and/or repair information.

Water Contamination

When troubleshooting a sample failure alarm check for any water in the moisture sensor bowl or a high cooler temperature. To find the cause of the water contamination, proceed as follows:

1. Check to see that the temperature of the sample gas cooler is at least 35°F.
2. Remove, dry out, and replace the moisture sensor filter elements.

Routine Maintenance for the Sample Probe

The probe has no moving parts. It does have a particulate filter and an electric heater. The electric heater can be checked by using a clamp-on AC amp meter to detect current on the power wires going from the analyzer cabinet into the sample line up to the probe. The probe also has a low temperature alarm contact that will detect an inoperable probe heater. The filter is manually checked as part of scheduled routine maintenance as described later.

Routine Maintenance for the Sample Line

The sample line requires no maintenance. However, it is advisable to periodically inspect the sample line visually to detect any damage or wear due to rubbing, vibration, physical damage, etc. If the sample line is installed properly there should be no stress points that could cause the tubing to become kinked in any manner. Typical life of the sample line heat trace is approximately 10-12 years depending on the temperature maintained and ambient conditions. Sample line heat trace is not a serviceable item and thus would require replacement in its entirety.

Routine Maintenance for the Sample Conditioning Unit

Depending on the quality of the ambient air the cooling fin block should be blown out with compressed air from time to time. In addition:

1. Insure sample pump is operating properly
2. Insure condensate pump is operating correctly

NOX Converter Check

This check is performed to ensure that the majority of the NOx component of the stack gas is able to be converted by the NOx analyzer into NO to be measured. The NOx converter element of a NOx analyzer has a typical life span of 2,000 ppm hours, roughly about a 2-5 year lifespan. NOX converter degradation is not easily detected during normal operation and daily calibrations. NOX converter failure will be detected during a relative accuracy test audit, as the reference method NOX measurement will not agree with the stack measurement. This procedure should be performed annually, before the RATA.

1. Select a protocol gas cylinder having an NO_2 concentration that is 20%-25% of the NOx analyzer's span value, with the balance of the cylinder being air or nitrogen. No other gases may be present in the cylinder.
2. Perform a calibration check to ensure that the analyzer is not out-of-control. Make adjustments and re-check the calibration as necessary.
3. Place the system into maintenance mode. Inject the NO_2 gas and check cylinder regulator pressure to ensure that the flow rate is 2 liters per minute.
4. Flow the gas until stable readings are reached (approximately 10 minutes). If the resulting stable reading is 90%-100% of the cylinder target value, the NOx converter is converting the NO_2 properly. Any lesser amount of conversion indicates that the NOx converter needs to be replaced. If the converter is replaced, perform a follow up converter check to ensure that the problem was resolved.
5. Note in the CEMS maintenance log book when the converter check was performed, results of the check, and if the converter was replaced.

CEMS Preventive Maintenance Schedule

This section contains a suggested schedule for performing preventive maintenance. Maintenance schedules may vary depending upon site-specific conditions (that is, filters may need to be changed more often in a "dirty" environment or less often under "clean" conditions). For detailed maintenance, procedures refer to the manufacturer's instruction manuals and other technical data included separate cover.

Some items, such as filter checks, may not exhibit a failure condition until damage has occurred to other components. Initially, these items will require careful and frequent checking to determine replacement frequency specific to individual applications. Any changes of the operating characteristics of the system should trigger a maintenance response to prevent loss of data and/or equipment damage. This includes paying attention to any shift (sudden or prolonged) in one direction and close observation of the visual indicators in the system.

CEMS alarms indicate that service is required. They do not necessarily indicate that the collected data is invalid. The alarms do indicate that the system is operating outside of design tolerance and incorrect data and equipment damage will occur if the system continues operation without corrective action. For this reason, the alarms themselves should be tested on a regular basis to assure that they are operating as designed. All alarm conditions require quick attention and resolution.

Prior to performing any maintenance call the control room to let them know that you will be working on the system and possibly affecting emissions data. Any time maintenance is performed place the system into maintenance mode. This will flag the data in the database and prevent data from being used in hourly average calculations.

Periodically evaluate the maintenance activities to identify trends. If sample flow rates change by a large amount over time, it may indicate that the probe is plugged. If the vacuum pump differentials change dramatically, it may indicate excess moisture in the system. Be alert for both gradual and sudden changes in system operation.

Important Note: In accordance with some local regulatory compliance requirements, certain types of maintenance events may trigger the need to perform diagnostic testing and/or recertification to ensure that the CEMS has been returned to optimum operating condition after the maintenance activity. A manual calibration is required after completion of most routine maintenance repair events. Major repair and/or complete replacement of an analyzer or other major equipment component may require partial or full recertification of the repaired/replaced instrument. Always consult with the local regulatory agency on any issues regarding major equipment repair or replacement along with any required post maintenance activity test requirement.

General Warnings: The technicians performing maintenance should be familiar with all safety warnings contained in the individual manufacturer's manuals. Most components need to be powered off before major maintenance to prevent potential electrical shock hazards.

Some components can be damaged by small amounts of static electricity. Before performing any maintenance, use a properly grounded antistatic wrist strap to be worn while handling any instrument's internal components.

Some components such as the probe or heating elements on some analyzer types may be extremely hot to the touch. Wear protective heat-resistant gloves when handling.

Other components such as optical assemblies and capillaries in the analyzers are made of glass and must be handled carefully.

Be careful about using solvents or abrasive materials for cleaning. Check manufacturers' manuals for recommended cleaning materials and procedures.

8 Operations & Maintenance Checklists

The following items should be included in CMMS work orders for regularly scheduled inspection and maintenance of CEMS.

8.1 Daily:

- date of activity and technician's name
- record the CEMS shelter temperature (should be between 70 – 75 deg. F)
- sample system
    - check for normal operation of the sample pump
    - check for normal operation of the cooler drain pumps; rotation at ~ 6 rpm
    - check moisture traps
    - check total sample flow meter; flowrate = 5-7 l/m
    - check analyzer flow meters; flowrate = 0.5 l/m
    - check daily calibration gas bottle pressures
        - replace if below set points; order new cal gases when needed keeping in mind the lead time required for some cal gas mixtures
- DAHS system
    - check DAHS for normal operation; system is logging data
    - check and archive alarms; log reason codes and action codes for any alarm conditions
    - check CE test report for all analyzers/monitors; respond immediately to failures
    - print, review, initial, and file all daily summary reports
    - watch for and immediately report to supervisor any non-compliance / exceedance episodes
    - initiate corrective actions as needed
- analyzers
    - check for error messages
- additional notes
    - ensure system has been placed in Maintenance Mode before performing any maintenance or repair
    - log all activities in CEMS log book
    - immediately report non-compliance to Compliance Manager
    - log all available information regarding non-compliance events, including date, time, persons notified, correct actions taken
    - CE test issues:
        - check results as soon as cal period finishes.
        - if cal fails, recalibrate within 15 minutes
        - initiate a calibration after each new cal gas bottle
        - initiate a calibration after each startup
        - initiate a calibration after any maintenance/corrective action event to check operating condition of the analyzers

8.2 Weekly

- sample system
  - check moisture sensor and tubing downstream of sample conditioner for moisture
  - remove and dry as necessary
  - check sample conditioner for proper operation
- DAHS system
  - check/change backup media (CD disk, tape, etc.)
  - if enabled, verify that automatic backups have occurred for the week
  - verify there is sufficient disk for another week of data

8.3 Monthly

- sample system
  - check sample pump; replace diaphragms and disks as needed, usually every 4 months
  - check cooler peristaltic drain pump tubing, replace as necessary
  - perform manual calibration per following SOP
  - check the in-line filter and change as needed per SOP
- check CGA cal gas bottle pressures > 500 psig; order new gas bottles as needed keeping in mind the lead time is several weeks

8.4 Quarterly

- sample system
  - if sample gas pressure shows a decline, perform probe maintenance; replace the probe filter element and clean the filter chamber as necessary; replace O-rings; verify probe box heater is operating
  - if flow is low, check sample pump
- analyzers
  - inspect capillaries for blockage; clean as needed
  - inspect ozone restrictor; replace if it becomes plugged
  - check for leaks around fittings
- perform CGA

8.5 Annually

- sample system
  - inspect and clean thermoelectric cooler fan
- analyzer
  - perform NO_2 to NO converter efficiency check
- perform RATA

9 Troubleshooting and Corrective Maintenance

9.1 Introduction

This section contains information on performing troubleshooting and corrective maintenance. For detailed procedures refer to the manufacturer's instruction manuals and other technical data included under separate cover. The technician should be familiar with the material in these manuals before attempting any troubleshooting.

Note: The CEM should be recalibrated after completion of any corrective or preventive maintenance procedure that may have affected analyzer performance.

9.2 Troubleshooting the System

The following list outlines common problems that may be encountered with the CEMS sample conditioning system.

- power failure
  - check circuit breakers
  - check power wiring
  - check alarm system inspect and clean thermoelectric cooler fan
- heat trace failure
  - check sample line temperature
  - check voltage/current for heated sample line
  - check line for external damage
- loss of sample
  - check sample pump motor, wiring, diaphragm and seals
  - check sample vacuum (probe vacuum)
  - check sample gas cooler
  - check moisture/conductivity sensor
  - adjust back pressure regulator
  - check gauges for sticking or fouling
  - check in-line particulate filter and sample line for blockage/leaks, proper connection
  - check analyzer vents for blockages
  - remove, clean, repair or replace sample line components causing flow restrictions
- high vacuum
  - check probe for blockage
  - check sample line for blockage
- water in line
  - check temperature alarm of sample gas cooler
  - check sample line heating
  - peristaltic drain pump is inoperative

- solid state conductivity sensor needs replacing

For specific analyzer information regarding preventive maintenance, troubleshooting, corrective maintenance, and parts please refer to the appropriate manufacturer's recommendations in the manufacturer's manuals in Appendix C.

Appendix A – Record of Revisions

This log is provided for use in documenting updates of the plan and resubmittal to the air authority.

Significant revisions to this plan shall be captured on this log and require resubmittal to the SCAQMD.

Other revisions such as editorial, personnel changes or telephone numbers shall be made by the facility and recorded in the log.

Change No.	Date Entered	Initials	Description of Change	Page No.
0	6/5/2014	CJB/BG	Plan Revised and Issued	All

Appendix B – Permits and Approvals

- California Air Resources Board (CARB) Amendments and Public Comments, June, 1988
- Monitoring and Enforcement Agreement, May 10, 1989
- Monitoring and Enforcement Agreement Compliance Summary Matrix, January 26, 1993
- SCAQMD CEMS Final Certification Letter, June 28,1994
- US Environmental Protection Agency (EPA) Title V Permit to Operate – Permit No. CB-OP 99-01, August 1, 2000
- US Environmental Protection Agency (EPA) Approval to Modify, Including Amendments through August 14, 2003; refers to 40 CFR 60 Performance Specifications
- EPA Title V Air Permit Limits Matrix, November 12, 2013
- SCAQMD Form ST-220 CEMS Modification Application, Boiler 1, January 10, 2014
- SCAQMD Form ST-220 CEMS Modification Application, Boiler 2, January 10, 2014
- SCAQMD CEMS Modification Approval Letter, January 22, 2014

Appendix C – CEMS Components Manufacturers Manuals

- CiSCO System Manual
- Universal Analyzers Model 1090 Sample Cooler Manual
    - http://www.universalanalyzers.com/Manuals/man1090revg.pdf
- California Analytical Instruments ZRE NDIR/O_2 User's Manual
    - file:///C:/Users/Priority%20One%20CEMS/Documents/Priority%20One/Desert%20View/ZRE_CAI_OPERATORS_MANUAL.pdf
- Ametek/Thermox Model WDG-Insitu Flue Gas Analyzer Manual
- Teledyne Monitor Labs Lighthawk 560 Dual Pass Opacity Manual
    - http://www.teledyne-ml.com/pdf/lh560manual.pdf
- Dieterich Standard Model 70 Annubar Manual
- CiSCO CeDAR User's Guide

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